

THE RÔLE OF THE BASAL PLATE OF THE TAIL IN
REGENERATION IN THE TAIL-FINS OF FISHES
(*FUNDULUS* AND *CARASSIUS*)

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Experiments on the tails of fishes from a standpoint of morphogenesis have been performed by Morgan (1900, 1902 and 1906), and by the writer (1929). A review of the literature may be found in Nabrit (1929).

The writer suggested in the previous paper, after comparing the findings of Harrison (1918) and Detwiler (1918) in *Amblystoma* with the results of his experiments in fishes, that a possible similarity existed between the production of limbs in *Amblystoma* and tail-fins in fishes. Each one seems to be an independently differentiating mesenchymal system.

It was further concluded that the rate of regeneration from cut surfaces in the tail-fins of fishes is regulated by the cross-sectional area of the fin rays exposed.

Brousseau (1786), Morgan (1906), and Morrill (1906) agreed that ray stumps must be left for regeneration to take place. Morrill suggested that regeneration does not take place when the remaining stumps are too small. This point was left open for further investigation by the writer and is considered in this paper.¹

The experiments were carried out during the summer of 1929 at the Marine Biological Laboratory at Woods Hole, Massachusetts, and during the winter of 1929-1930 at Morehouse College. At Woods Hole, *Fundulus heteroclitus* was used and at Morehouse College, the goldfish, *Carassius auratus*. In both cases, adult animals were used.

Rays were carefully picked from the tails by fine forceps. The tail and the rays were examined under a binocular microscope to make sure that no parts of the rays were left embedded in the tails.

After regeneration was complete, examinations were made upon the living and then upon the fixed tails.

In three weeks after removing the fin rays, undifferentiated mesen-

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chyme had filled in the gap made in the tails. In from four to six weeks, rays appeared in the regenerated mesenchyme (*a*, Figs. 1 and 2). These rays begin at the basal plate and differentiate distally. They segment and may branch as any other rays in the tail, though some rays do not branch (*b*, *c*, Figs. 1 and 2). If they branch at all it is usually dur-

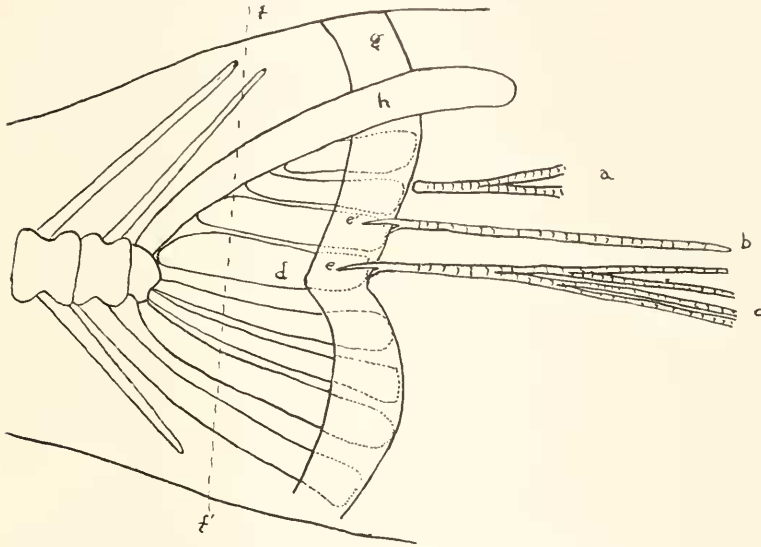


FIG. 1. *Carassius*. Diagrammatic sketch of the base of the tail.

- a*. A newly regenerated ray (six weeks).
- b*. A ray six months after it started regeneration. It did not branch.
- c*. A regenerated ray after six months.
- d*. Basal plate.
- e* and *e'*. Proximal end of fin ray.
- ff'*. Region of a cut anterior to proximal end of fin rays.
- g*. Articulating region of basal plate.

ing the first two months. The anterior knobs or proximal ends of the rays are completed in from five to six months (*e*, *e'*, Figs. 1 and 2). The proximal ends are produced on both sides of the basal plate.

In the embryonic development of the tail in *Fundulus*, the rays streak out from a common mesenchymal plate. They begin to appear between the ninth and thirteenth days. From two to four appear at a time, dorsally and ventrally placed in respect to the previously formed rays.

When a cross-cut is made in the tail anterior to the proximal knobs of the fin rays (*ff'*, Figs. 1 and 2), regeneration does not readily take place. This led to the conclusion that the ray stumps must be left in the tail for regeneration of the tail to occur.

When rays are picked out of the tail, they readily regenerate; the

rate, however, is slower than it would be if ray stumps were present. It would appear, therefore, that no parts of the rays are necessary for regeneration.

New rays do not begin to appear at their original most proximal point, but at the distal end of the basal plate. Physically this is necessary unless two separate anlage are developed for each ray, as each ray has a component on each side of the basal plate.

When a cross-cut is made anterior to the proximal knobs of the fin rays, the cut also includes the anterior articulating portion of the basal

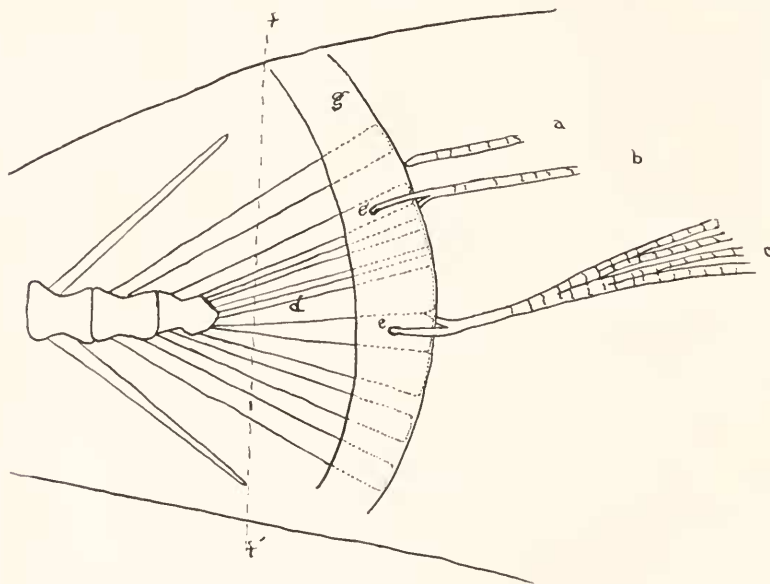


FIG. 2. *Fundulus*. As above.

a. New ray, three and one-half weeks.

b. A ray, six and one-half weeks.

c. A normal ray.

d. Basal plate.

e and e'. Proximal end of fin ray.

ff'. Region of a cut anterior to proximal end of fin rays.

g. Articulating region of the base of tail.

plate. In such a case the delay in regeneration would be so great that the animal would be cast aside, even if, as is usually the case, the flesh did not slough off and lead to death.

A cut ray will regenerate those parts distal to the level of the cut. An anterior knob regenerates the entire ray. Axial heteromorphosis on the knob has not occurred. But when an anterior knob is severed or removed from the distal stump, axial heteromorphosis occurs in the dis-

tal portion. When a ray is picked out, on the other hand, the new distal portion appears at the end of the articulating portion of the basal plate. Now instead of getting axial heteromorphosis with this distal portion, there is added a normal anterior knob. The visible difference in these two cases is that this new ray is in connection with the basal plate. It thus seems evident that the basal plate gives rise to the parts distal to it, or induces their development. This suggestion gains further support from the fact that the articulating part of the basal plate is shaped like the tail in *Carassius* and in *Fundulus*, bilobated in the former and rounded in the latter, and may still retain the original formative influences which cause the differentiation of the fin rays and hence the size and form of the tail.

It seems that a further similarity is demonstrated between the morphogenesis of tail-fins of fishes and the *Amblystoma* limbs. The articulating plate, like the girdle, may give rise to parts distal to it. In regeneration as in embryonic development, the basal plate gives rise to or induces the development of rays. The rays, like the limbs in *Amblystoma*, and the basal plate, like the girdle, belong to a self-differentiating mesenchymal system.

SUMMARY

1. By picking out the fin rays instead of cutting anterior to them, it is shown that ray stumps are not necessary for regeneration in the tail-fins of fishes.
2. When the stumps are removed it seems that the new rays appear under the influence of the articulating portion of the basal plate of the tail.
3. From the embryological development and mode of regeneration a similarity is demonstrated between morphogenesis of limbs of *Amblystoma* and the tails of fishes, each being a self-differentiating mesenchymal system.

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